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REPORT OF

INSPECTION OF PLASTER WORK AT

ALASKA NATIVE SERVICE HOSPITAL

AND TESTS FOR QUALITY AND

CHARACTERISTICS OF PLASTER MATERIALS


By

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Requested by the

Bureau of Indian Affairs

REPORT OF INSPECTION OF PLASTER WORK
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TESTS FOR QUALITY AND CHARACTERISTICS
OF PLASTER MATERIALS

## 1. INTRODUCTION

Pursuant to a request from the Bureau of Indian Affairs, Department of the Interior, dated February 13, 1953, an inspection was made to determine the condition of plaster in the main hospital building and the quarters buildings for nurses and help at the Alaska Native Service Hospital, Anchorage, Alaska, on February 21, 22, 23, 1953. Participating in the inspection were Messrs. Lansing S. Wells, William C. Cullen, and Nolan D. Mitchell of the National Bureau of Standards. The report of this inspection and related tests supplement a letter of this Bureau dated June 16, 1952, and a report 9.8/G-10015 dated September 17, 1952, both signed by Lansing S. Wells.

Among representatives of the Department of Interior, Bureau of Indian Affairs, who were contacted at the job were:

Mr. John J. Finley, Chief, Building & Utilities Branch, Wash., D.C.
Mr. L. T. Burn, Architectural Engineer, Bldg. & Util. Br., " "
Mr. H. T. McCurdy, Chief, Mech. Engineers, " " " " "
Mr. J. C. Helfrich, Electrical Engineer, " " " " "
Mr. Harry Halverson, Area Chief,
Bureau Indian Office, Juneau, Alaska
Mr. V. P. Reimer, Project Engineer,
Alaska Native Service Hospital, Anchorage, Alaska

## 2. INSPECTION OF QUARTERS BUILDING

The first inspections were made in the quarters building because the construction there was nearing completion. Fifteen of twenty rooms and the corridors in the help's quarters section were found to have cracks in the plaster. Cracks were observed in rooms 200, 201, 207, 209, 212, 214, 215, 217, 303, 309, 311, 321, 325, 329, 331, and in the corridor wall in the vicinity of room 303. A number of cracks extended from the corners of electrical outlet boxes. Some of the ceiling cracks extended from electrical outlets toward the walls. The direction of the larger wall cracks was usually more or less vertical. Many of these more prominent cracks were intersected by narrower cracks extending laterally from the main cracks. Many of the thin cracks were in random directions in a pattern known as map cracking.

Not only were there cracks in the plaster but a number of the ceramic wall tiles in the wainscots of bathrooms and toilet rooms were found to be broken, and in a number of places wall tiles were found to be loose from the backing of portland cement plaster on metal lath. Wall tiles were removed from the wainscot in one location, and equally spaced horizontal shrinkage cracks in the cement plaster base were observed in the height of the wainscot.

## 3. INSPECTION OF MAIN HOSPITAL BUILDING

The inspection of the Hospital Building to determine the condition of the plaster included visits to approximately sixty percent of the total number of rooms and all corridors. A careful inspection of the condition of the concrete of the exterior walls was also made to determine whether defects of concrete work might have contributed to the failure of the plaster. The plaster on metal lath for corridor and room partitions, without exception, was found to be cracked or had been cracked and repaired. A large proportion of the plaster surfaces had been painted, but cracking appeared to have continued subsequent to the application of the paint. There were few boxes for outlets for electrical services where cracks were not found to radiate from one or more corners. The general cracking was of the pattern known as map cracking. The spacing of cracks ranged from a few inches to about three feet.

Specimens of plaster for laboratory tests and analyses were cut from rooms and corridor as shown in table 1. The 15- by 15-inch specimens as cut from partitions for tests to determine the stability of the plaster when subjected to changes in relative humidity included the metal lath as well as the plaster. Those for analysis to determine the proportions of plaster and aggregates were approximately 10 inches square and did not include lath or plaster keys.

Table 1. Source or location of specimens of lath and plaster for laboratory tests

| Story | Wing | Room | Tests |
|---|---|---|---|
| Basement | South | Corridor | Analysis and stability |
| Do | do | 12 | Analysis |
| First | East | 106 | Analysis and stability |
| Do | West | 182 | Stability |
| Second | North | 245 | Analysis |
| Third | East | 316 | Analysis |
| Do | West | 318 | Stability |
| Fourth | South | 438 | Analysis |
| Fifth | West | 504 | Analysis |
| Do | South | 523 | Stability |
| Do | do | (Closet) 523 | Stability |

4. MATERIALS FOR AUXILIARY TESTS

Bags of materials were secured from the same sources from which plaster, lime, and aggregates for the building plaster came. The gypsum cement plaster, gauging plaster, and finishing lime were bought from Pioneer Sand and Gravel Co., 901 Fairview North, Seattle, Washington. The plaster supplied by this concern was from the Sigurd, Utah, plant of United States Gypsum Co., and the lime was "Miracle" brand from U. S. Lime Products Corporation, Henderson, Nevada. The vermiculite aggregate was from the Portland, Oregon, plant of Vermiculite Northwest, Spokane, Washington, and the sand was obtained by Mr. V. P. Reimer, Project Engineer, from Anchorage, Alaska, who also forwarded retained samples of plastering materials from his office.

5. CHARACTERISTICS OF PLASTERS

Characteristics of the plasters and hydrated lime are given in tables 2 and 3. These materials conform to applicable Federal specifications. Analyses of plaster materials found in specimens of the set plasters are given in tables 4, 5, and 6. The proportions of gypsum cement and aggregates in the set-plaster samples were determined by dissolving the gypsum from weighed amounts of dried set plaster in ammonium acetate solution, then washing and weighing the residue after it had been dried at 70° C. The gypsum cement plaster was found to be 96.15 percent soluble; therefore, when the weight of the soluble portion of the sample of set plaster was divided by 0.96, the quotient gave the weight of the gypsum plaster from which the percent of gypsum plaster in the mix was computed. The ratio of sand to vermiculite in the aggregates was determined from the weights of the two constituents. It was found that the sand used in the plaster had a fairly definite proportion of a magnetic constituent. By the use of a magnet a large part of the magnetic material could be extracted from the mixture of aggregates. It was reasoned that the ratio of magnetic material extracted from the mixed aggregate to that of magnetic material extracted from the sand would be the ratio of sand to that of the combined aggregates. The proportions of sand and vermiculite and the number of cubic feet of each per 100-lb. bag of gypsum plaster were computed on that basis.

Table 2. Characteristics of gypsum plasters

[By Federal Specification SS-P-402, except as otherwise stated]

| Plaster sample designation | Type | Time of set | Tensile strength | Compressive strength | $CaSO_4.1/2H_2O$ |
|---|---|---|---|---|---|
| | | hrs | psi | psi | % |
| U. S. Gypsum, fibered[1] | N | 24 | 190 | --- | 90.9 |
| U. S. Gypsum, not fibered[1] | N | 10 1/2 | 225 | --- | 90.3 |
| U. S. Gypsum, medium set gauging[1] | G | 2 1/4 | 540 | --- | 93.0 |
| U. S. Gypsum, fibered[2] | N | 7 1/2 | 240 | [3] 1190 | 92.8 |
| Do (with Alaska sand) | N | 5 1/4 | 185 | [3] 1030 | |
| Do (Fed. Spec. SS-P-401) | N | 8 | 350 | [3] 1930 (avg. 2 lots) | |
| Do (Fed. Spec. SS-P-401, but with 150 g needle for consistency | N | --- | 365 | [3] 1880 | |
| U. S. Gypsum gauging[2] | G | 2 | 540 | 2470 | 98.3 |

[1] Sample of plaster approved for project.

[2] Sample purchased from dealer who supplied material for project. All of 25 g of gauging plaster passed through No. 100 sieve.

[3] The cubes of the four plaster mixes in this group exhibited volumetric shrinkage as follows: 2.0 percent; 0.6 percent; 2.2 percent (avg.of 2 lots); and 3.0 percent, respectively.

age, Alaska

| $CO_2$ (non-volatile basis | $MgO \div CaO + MgO$ | Total MgO hydrated | CaO + MgO unhydrated | Autoclave expansion |
|---|---|---|---|---|
| % | | % | % | % |
| 0.70 | 40.9 | 97.3 | 0.81 | --- |
| .94 | 40.5 | 97.9 | .62 | --- |
| 2.59 | 39.6 | 97.3 | .78 | 0.03 |

1/

Table 3. Characteristics of hydrated lime used in white-coat plaster for Alaska Native Service Hospital, Anchorage, Alaska
(Basis: room temperature)

| Sample designation | Fineness through | | Plasticity | Oxide content | | | | | Compound composition | | | | | CaO + MgO (nonvolatile basis) | $CO_2$ (nonvolatile basis) | MgO ÷ CaO + MgO | Total MgO hydrated | CaO + MgO unhydrated | Autoclave expansion |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | #30 | #200 | | $CO_2$ | $H_2O$ | $SiO_2 + R_2O_3$ | CaO | MgO | $CaCO_3$ | $Ca(OH)_2$ | $Mg(OH)_2$ | MgO | $SiO_2 + R_2O_3$ | | | | | | |
| | % | % | | % | % | % | % | % | % | % | % | % | % | % | % | | % | % | % |
| U.S. Lime Products Corp. "Miracle" dolomitic, pressurized (small can) | 100.0 | 95.1 | [illegible] | [illegible].50 | 26.47 | [illegible].85 | 42.87 | 2[illegible].68 | [illegible].14 | 55.80 | 41.77 | 0.81 | [illegible].85 | 99.3 | 0.70 | 40.9 | 97.3 | 0.81 | --- |
| Do (medium can) | 100.0 | 93.2 | 580 | .69 | 26.51 | [illegible] | 4[illegible] | 2[illegible].44 | 1.57 | 56.06 | 4[illegible].70 | .62 | .63 | 99.0 | 94 | 4[illegible].5 | 97.9 | .62 | --- |
| Do [1] | 1[illegible].0 | 93.2 | 430 | 1.85 | 25.50 | 69 | 43.32 | 2[illegible].39 | 4.21 | 54.12 | [illegible].95 | .78 | .69 | 98.7 | 2.50 | 3[illegible].6 | 9[illegible].3 | .78 | [illegible].03 |

[1] Lime purchased from dealer who supplied materials for the project. All other samples were retained approved samples from the project.

Table 4. Analysis of base-coat plaster for proportion of aggregates by ammonium acetate method
(Basis: Material dried at 50° C)

| Sample designation | Weight of sample | Total insoluble | Total insoluble | Magnetic content extracted |
|---|---|---|---|---|
| | g | g | % | g |
| U.S. G. "Red Top" fibered gypsum plaster[1] | 3.9945 | 0.1490 | 3.73 | --- |
| Do | 5.0030 | .1925 | 3.85 | --- |
| Do | 5.0037 | .1948 | 3.89 | --- |
| Do | 5.0032 | .1992 | 3.98 | --- |
| Do | 5.0033 | .1901 | 3.80 | --- |
| | | | (Avg. 3.85) | |
| Vermiculite[2] | 4.9975 | 5.0072 | 100.19 (Soluble: none) | 0.0000 |
| Alaska sand[3] | 19.9500 | 19.8635 | 99.57 (Soluble: 0.43) | .7920 (Avg. of 6 determinations) |
| Base-coat plaster[4] | | | | |
| B hall | 9.9905 | 4.6338 | 46.78 | 0.1565 |
| Do | 10.0025 | 4.5300 | 45.29 | .1580 |
| Average | 9.9965 | 4.5819 | 46.04 | 0.1568 |
| N 12 | 9.9875 | 3.2155 | 32.20 | .0318 |
| Do | 10.0010 | 3.4143 | 34.14 | .0320 |
| Average | 9.9943 | 3.3149 | 33.17 | 0.0319 |
| E 106 | 9.9860 | 2.5108 | 25.14 | --- |
| Do | 10.0005 | 2.6432 | 26.43 | 0.0000 |
| Do | 10.0015 | 2.6422 | 26.42 | .0000 |
| Average | 9.9996 | 2.5991 | 26.00 | 0.0000 |
| N 245 | 9.9900 | 3.4605 | 34.64 | 0.0500 |
| Do | 10.0007 | 3.5407 | 35.40 | .0375 |
| Average | 9.9954 | 3.5006 | 35.02 | 0.0438 |
| E 316 | 9.9925 | 5.4580 | 54.99 | 0.1240 |
| Do | 10.0005 | 4.5940 | 45.94 | .1250 |
| Do | 10.0000 | 4.6195 | 46.20 | .1265 |
| Average | 9.9978 | 4.8905 | 49.04 | 0.1252 |
| S 438 | 9.9900 | 4.4018 | 44.06 | 0.0915 |
| Do | 10.0002 | 4.4860 | 44.86 | .0915 |
| Average | 9.9951 | 4.4439 | 44.46 | 0.0915 |
| W 504 | 9.9800 | 3.4795 | 34.86 | 0.0650 |
| Do | 10.0005 | 3.7210 | 37.21 | .0560 |
| Average | 9.9903 | 3.6003 | 36.04 | 0.0605 |

[1] Sample of plaster from dealer who supplied plaster for project.

[2] Sample of vermiculite aggregate from Vermiculite Northwest who supplied aggregate for project.

[3] Sample of sand supplied by Project Engineer as representative of material used on project.

[4] Base-coat plaster samples taken from walls of hospital building. Letters signify, respectively: B, basement; N, North; E, East; S, South; W, West, and figures denote the room number as given on architectural plans. The proportion of aggregates were determined from analyses of these samples.

e, Alaska

| Sample designation[1] | gO e ed | Ratio, lime putty to $CaSO_4.1/2H_2O$ in original mix | Apparent MgO in lime used | Thickness of the white coat |
|---|---|---|---|---|
| | | | % | in. |
| B hall | 11 | 3.5+ | 41.4 | <1/64 - 1/16 |
| N 12 | 10 | 0.95+ | 40.0 | 1/16 - 3/32 |
| E 106 | 11 | 2.0- | 38.7 | 1/32 - 1/16 |
| N 245 | 10 | 1.3- | [2] 47.9 | 1/32 |
| E 316 | 10 | 3.3- | 39.6 | 1/32 - 1/16 |
| S 438 | 12 | 1.4- | 39.8 | 1/16 |
| W 504 | 4 | 0.81- | [2] 51.7 | <1/64 - 1/16 |

[1] Letters signify .

[2] Samples designat mineral containing a considerable percentage of MgO) from the base coa on the assumption that the white coat consists of nothing other tha

[3] The excess $H_2O$ r

Table 4. Analysis of base-coat plaster for proportion of aggregates by ammonium acetate method
(Basis: Material dried at 50° C)

| Sample designation | Weight of sample | Total insoluble | Total insoluble | Magnetic content extracted |
|---|---|---|---|---|
| | g | g | % | g |
| U.S. G. "Red Top" fibered gypsum plaster[1] | 3.9945 | 0.1490 | 3.73 | --- |
| Do | 5.0030 | .1925 | 3.85 | --- |
| Do | 5.0037 | .1948 | 3.89 | --- |
| Do | 5.0032 | .1992 | 3.98 | --- |
| Do | 5.0033 | .1901 | 3.80 | --- |
| | | | (Avg. 3.85) | |
| Vermiculite[2] | 4.9975 | 5.0072 | 100.19 (Soluble: none) | 0.0000 |
| Alaska sand[3] | 19.9500 | 19.8635 | 99.57 (Soluble: 0.43) | .7920 (Avg. of 6 determinations) |
| Base-coat plaster[4] | | | | |
| B hall | 9.9905 | 4.6338 | 46.78 | 0.1565 |
| Do | 10.0025 | 4.5300 | 45.29 | .1580 |
| Average | 9.9965 | 4.5819 | 46.04 | 0.1568 |
| N 12 | 9.9875 | 3.2155 | 32.20 | .0318 |
| Do | 10.0010 | 3.4143 | 34.14 | .0320 |
| Average | 9.9943 | 3.3149 | 33.17 | 0.0319 |
| N 106 | 9.9860 | 2.5108 | 25.14 | --- |
| Do | 10.0005 | 2.6432 | 26.43 | 0.0000 |
| Do | 10.0015 | 2.6422 | 26.42 | .0000 |
| Average | 9.9996 | 2.5991 | 26.00 | 0.0000 |
| N 245 | 9.9900 | 3.4605 | 34.64 | 0.0500 |
| Do | 10.0007 | 3.5407 | 35.40 | .0375 |
| Average | 9.9954 | 3.5006 | 35.02 | 0.0438 |
| E 316 | 9.9925 | 5.4580 | 54.99 | 0.1240 |
| Do | 10.0005 | 4.5940 | 45.94 | .1250 |
| Do | 10.0000 | 4.6195 | 46.20 | .1265 |
| Average | 9.9978 | 4.8905 | 49.04 | 0.1252 |
| S 438 | 9.9900 | 4.4016 | 44.06 | 0.0915 |
| Do | 10.0002 | 4.4860 | 44.86 | .0915 |
| Average | 9.9951 | 4.4439 | 44.46 | 0.0915 |
| W 504 | 9.9800 | 3.4795 | 34.86 | 0.0650 |
| Do | 10.0005 | 3.7210 | 37.21 | .0560 |
| Average | 9.9903 | 3.6003 | 36.04 | 0.0605 |

[1] Sample of plaster from dealer who supplied plaster for project.

[2] Sample of vermiculite aggregate from Vermiculite Northwest who supplied aggregate for project.

[3] Sample of sand supplied by Project Engineer as representative of material used on project.

[4] Base-coat plaster samples taken from walls of hospital building. Letters signify, respectively: B, basement; N, north; E, east; S, south; W, west, and figures denote the room number as given on architectural plans. The proportion of aggregates were determined from analyses of these samples.

Table 5. Analyses of white-coat plaster finish from walls of Alaska Native Service Hospital, Anchorage, Alaska
(Basis: material dried at [illegible] C)

| Sample designation[1] | Oxide content | | | | | | Compound Composition | | | | | | | Total MgO of lime hydrated | Ratio, lime putty to $CaSO_4 \cdot 1/2H_2O$ in original mix | Apparent MgO in lime used | Thickness of the white coat |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ | $H_2O$ (combined) | $SiO_2+R_2O_3$ | CaO | MgO | $SO_3$ | $CaSO_4 \cdot 2H_2O$ | $CaCO_3$ | $Ca(OH)_2$ | $Mg(OH)_2$ | MgO | $H_2O$ excess | $SiO_2 + R_2O_3$ | | | | |
| | % | % | % | % | % | % | % | % | % | % | % | % | % | % | | % | in. |
| B hall | 11.87 | 21.16 | 1.12 | 35.62 | 18.02 | 12.49 | 26.86 | 26.99 | 15.52 | 26.07 | [illegible].72 | 0.00 | 1.12 | 79.4 | 3.5+ | 41.4 | < 1/64 - 1/16 |
| N 12 | 10.02 | 16.47 | 1.21 | 34.95 | 10.57 | 27.23 | 58.55 | 22.79 | 4.11 | 10.42 | 3.37 | 0.00 | 1.21 | 68.1 | 0.95+ | 40.0 | 1/16 - 3/32 |
| E 106 | 11.52 | 17.54 | 0.60 | 36.87 | 14.89 | 1[illegible].99 | 40.84 | 26.20 | 11.74 | 19.88 | 1.15 | 0.00 | 0.60 | 92.3 | 2.0- | 38.7 | 1/32 - 1/16 |
| N 245 | 10.02 | 18.27 | 0.61 | 32.70 | 14.83 | 23.69 | 50.94 | 22.79 | 4.41 | 21.16 | 0.20 | 0.00 | 0.61 | 98.7 | 1.3- | [2]47.9 | 1/32 |
| E 316 | 10.62 | 23.34 | 2.18 | 34.58 | 16.86 | 12.70 | 27.31 | 24.15 | 16.06 | 24.39 | [illegible].00 | [3]6.19 | [3]2.18 | 100.0 | 3.3- | 39.6 | 1/32 - 1/16 |
| S 438 | 12.22 | 17.47 | 1.09 | 34.51 | 12.44 | 22.38 | 48.13 | 27.27 | 5.00 | 18.00 | 0.00 | [3]0.62 | [3]1.09 | 100.0 | 1.4- | 39.8 | 1/16 |
| W 504 | 4.41 | 21.01 | 0.70 | 32.24 | 12.77 | 29.03 | 62.43 | 10.03 | 8.31 | 18.47 | [illegible].00 | [3][illegible].22 | [3]0.70 | 100.0 | 0.81- | [2]51.7 | < 1/64 - 1/16 |

[1] Letters signify, respectively: B, basement; N, north; E, east; S, south; W, west, and figures denote the room number as given on architectural plans.

[2] Samples designated N 245 and W 504, respectively, apparently show abnormally high percentages of MgO in the lime used. Possibly some vermiculite (a mineral containing a considerable percentage of MgO) from the base coat was carried mechanically into the white coat during the trowelling. If so, this would upset the validity of the calculations based on the assumption that the white coat consists of nothing other than lime and gypsum.

[3] The excess $H_2O$ may be attributed to unidentified minerals under $SiO_2 + R_2O_3$.

Table 6. Plaster aggregates in set gypsum plaster
(Computed from weights given in table 4)

| Sample designation | Proportion of sand in aggregate | Aggregates per 100-lb bag of gypsum cement plaster | |
|---|---|---|---|
| | | Vermiculite ($10\ lb/ft^3$) | Sand ($100\ lb/ft^3$) |
| | % | $ft^3$ | $ft^3$ |
| B hall | 90.0 | 3.0 | 2.70 |
| B 12 | 26.2 | 3.2 | .12 |
| E 106 | 6.0 | 3.0 | .06 |
| N 245 | 35.0 | 3.1 | .17 |
| E 316 | 66.8 | 3.9 | .56 |
| S 438 | 73.0 | 2.0 | .53 |
| W 504 | 45.3 | 2.7 | .23 |

## 6. STABILITY OF LATH AND PLASTER FROM THE HOSPITAL BUILDING

Five of the 15- by 15-inch specimens of lath and plaster cut from partitions of the basement, first, third, and fifth stories of the hospital building were sawn into 3 inch wide strips and subjected alternately to high and low or low and high humidity at nearly constant temperature. Changes in length between gage points 10 inches apart on 1/4-inch diameter thin brass discs cemented to the front and back surfaces of the plaster were measured by means of an optical comparator which was calibrated against a 10-inch invar standard bar at the time each set of readings was made. The changes in length shown by the differences of readings of the comparator indicated an initial shrinkage of many specimens followed by expansion when placed in an atmosphere having high humidity and shrinkage when in a container having low humidity.

The changes of length of the specimens in terms of percentage of the 10-inch gage length are shown in figures 1 and 2. These are typical of the behavior of the twenty-two specimens subjected to the tests. In some instances there appeared to be evidence that the expansion of the plaster caused flexing of the lath, thus producing marked or anomalous differences in the lengthening or shortening of the gage length of the specimens during the period in which it was subjected to a constant humidity. Some of these anomalies have been attributed to cracking of the base-coat plaster or both the base-coat plaster and the white-coat finish, thus allowing the metal lath, already strained by the shrinking plaster, to regain its length to the extent that the strain from shrinkage of the plaster had been relieved.

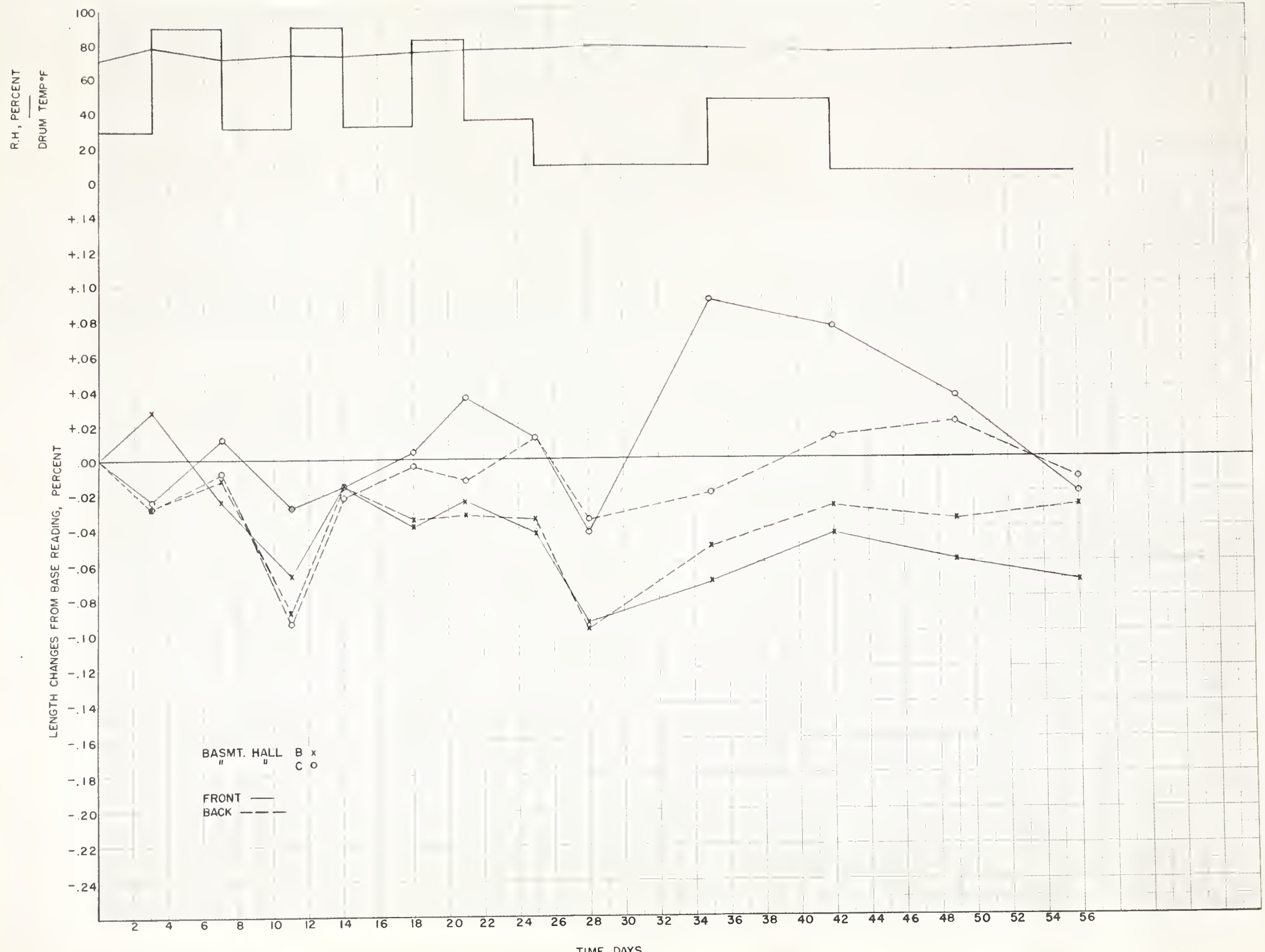



Figure 1. Changes in length of specimens of lath and plaster from basement corridor in percentage of a 10-in. gage length when subjected to changes in humidity.

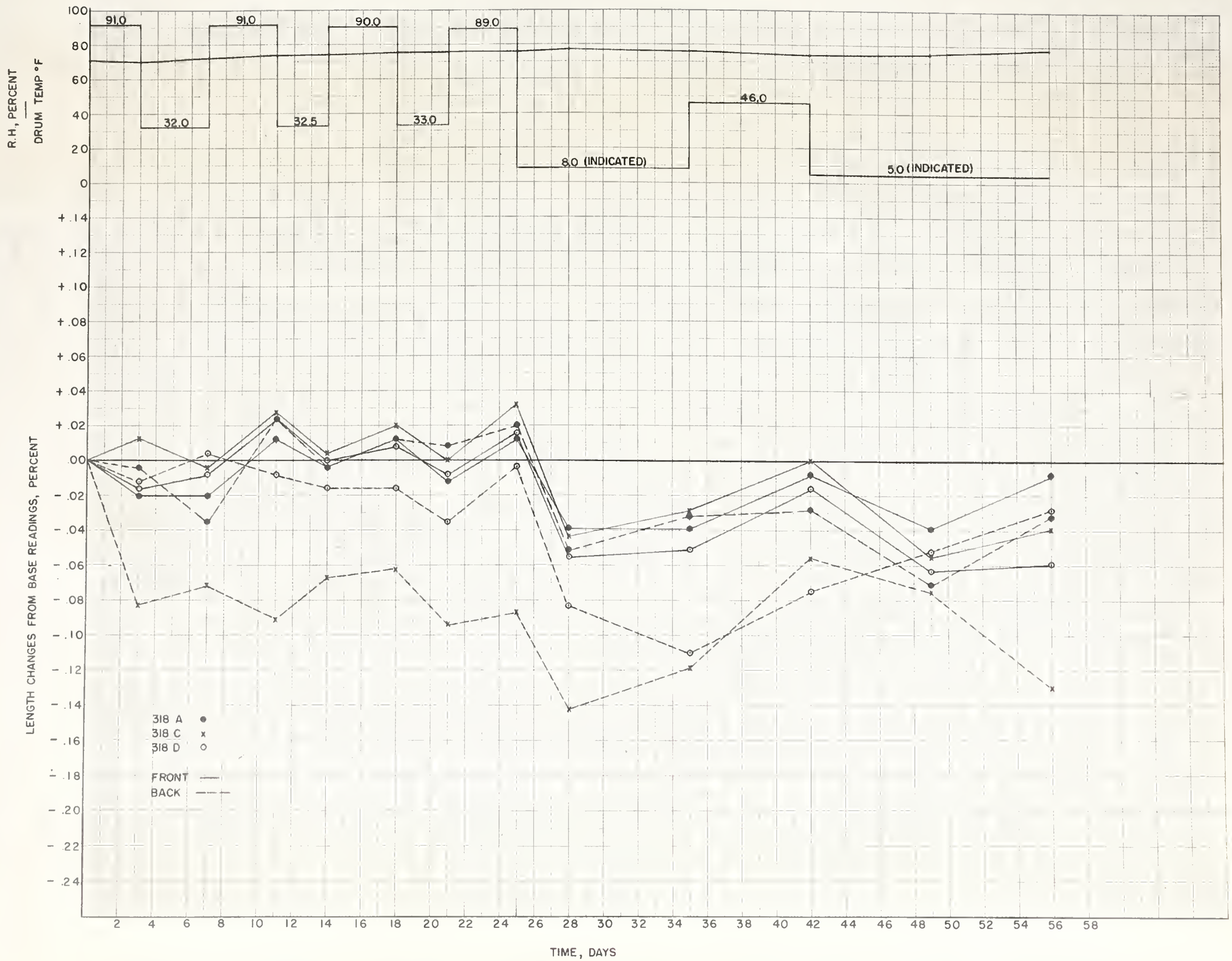
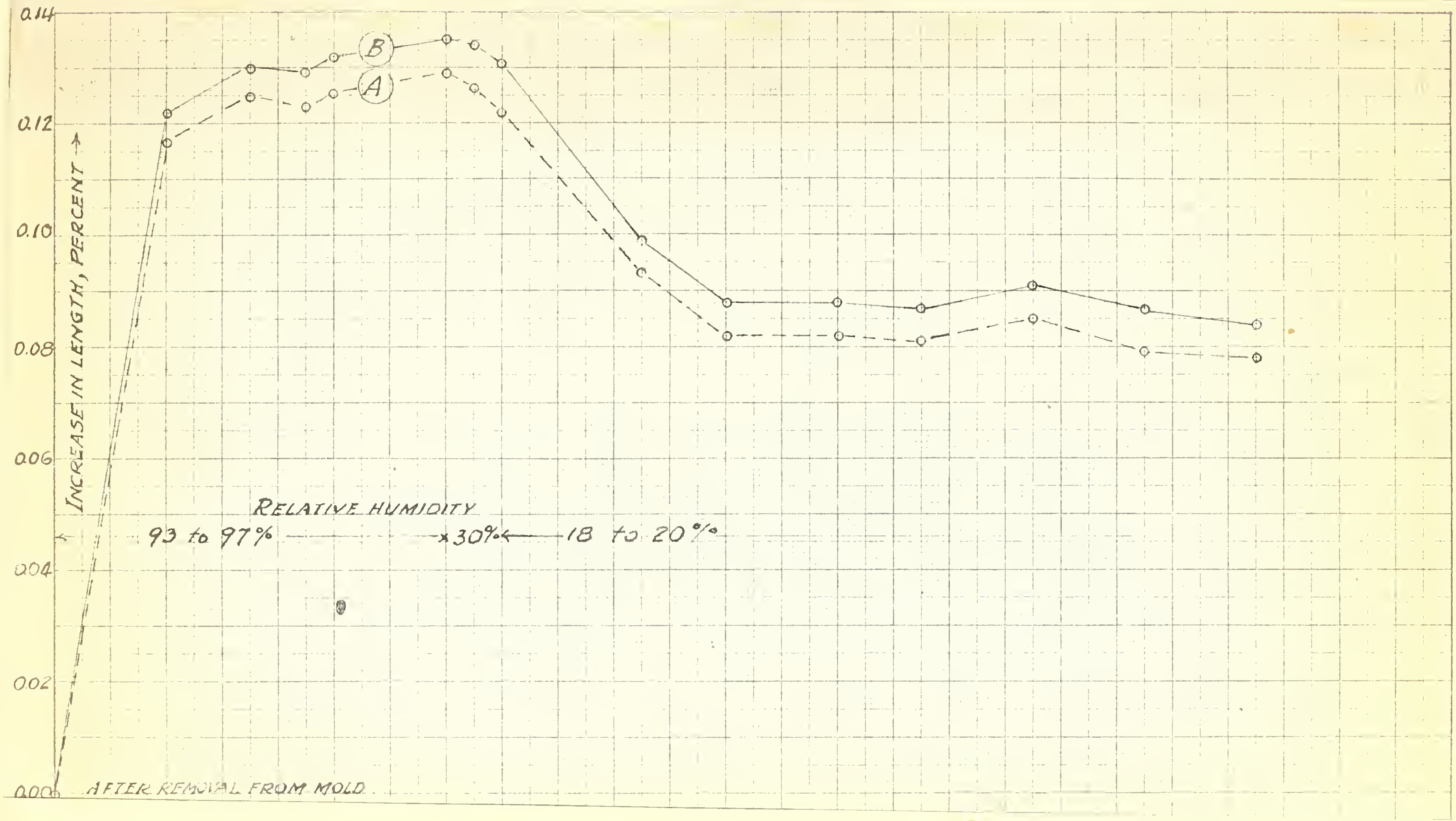



Figure 2. Changes in length of specimens of lath and plaster from room 318 in percentage of a 10-in. gage length when subjected to changes in humidity.

## 7. BEHAVIOR OF MOLDED PLASTER BARS

Two test bars of plaster designated A and B were cast in steel molds in order to study the behavior of the typical plaster mix when subjected to changing conditions of humidity. The bars were cast in molds to give an effective length of 10 inches between steel plugs cast into the ends of the bars. The bars were made from plaster having the composition: 20 parts fibered-gypsum cement, 8 parts vermiculite, and 5 parts Alaska sand by weight. Bar B had 10 percent more water in the mix than did bar A. The 1- by 7/8-inch bars had a 1/16 inch thick white finish applied to one face after they had been removed from the molds and measured for expansion. The changes in length of the two bars are shown in figure 3. On release from the constraint of the molds, the bars expanded 0.02 and 0.03 percent of their length at once, and after having lain horizontally without other restraint than their own weight for 4 days in a chamber at 70° F and at 93 to 97 percent relative humidity, the bars were found to have increased in length by 0.117 and 0.122 percent. During the next 10 days, at the same humidities, increases of 0.012 and 0.013 percent in length were observed, making the total expansion from the beginning of storage at high humidity 0.129 and 0.135 percent, respectively. The bars were then placed in a chamber held at 70° F and at 30 to 40 percent relative humidity for 2 days. The shrinkage during these 2 days amounted to not more than 0.007 percent. During the next 8 days, however, after storage in the chamber held at 18 to 20 percent relative humidity, the shrinkage amounted to 0.040 and 0.043 percent for specimens A and B, respectively. The shrinkage during the next 19 days, under the same humidity conditions, amounted to 0.004 percent. From the point of maximum expansion the shrinkage at the end of 29 days' storage in chambers in which the relative humidity was lowered by stages to 18 percent had reached 0.052 percent and appeared to be continuing.


0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
INCREASE IN LENGTH, PERCENT
B
A
RELATIVE HUMIDITY
93 to 97%
30%
18 to 20%
AFTER REMOVAL FROM MOLD

8. FLEXURE OF LATH AND PLASTER

Twelve specimens for tests to determine the amount of flexure of metal lath and plaster resulting from expansion or shrinkage of the plaster under different conditions of humidity were prepared. These were made by attaching 5 1/2 inch wide by 36 inch long strips of 3.4 lb. expanded metal lath to 1/4-inch diameter steel uprights mounted on a 6 by 1/8 by 36 inch long steel base plate. The uprights were spaced 16 inches on centers in two rows of three each. Two of the uprights of each row were welded in place while those at one end were fitted into holes in the base, so as to be removable. The lath strips were wired to the uprights so that one end of the lath would be free to flex after the removable upright had been removed.

Each coat of the base-coat plaster applied was made up of 20 lb. gypsum cement plaster, 8 lb. vermiculite, and 5 lb. of Alaska sand. After the batch had been well mixed it was halved. To one half, 14 lb. of water was added to give a relatively stiff mixture; to the other, 15 1/2 lb. of water was added to produce a comparatively soft mixture. The plaster coats were applied to the lath strips on two successive days to 11/16-inch thickness as determined by wood grounds, the drier mix being applied to the lath on the right-hand side of the base. After storage under wet burlap over night, the 12 specimens were transferred, four to each of three humidity chambers. The relative humidities in the three chambers into which the specimens were placed were 52, 72, and 92 percent.

The large amount of water in the specimens increased for a time the relative humidity above those fixed by the saturated salt solutions intended to keep the humidity at a constant level. After 3 days' storage of the specimens, a white-coat finish consisting of 4 parts lime putty to 1 part gauging plaster was applied to the set base-coat plasters to thicknesses ranging from 1/16 to 1/8 inches. The specimens were returned to the humidity chambers as soon as the white-coat finish had been applied.

4. Flexure of Lath and Plaster

Twelve specimens were made to determine the effects of flexure of metal lath and plaster resulting from expansion or shrinkage of the plaster under different conditions of humidity and temperature. These were made by attaching 1 1/2 inch wide by 16 inch long strips of 3.4 lb. expanded metal lath to 1/4-inch diameter steel dowels mounted in 2 by 6 by 1/4 by 24 inch long steel base plates. The specimens were spaced 12 inches on centers in two rows of three each. One of the ends of each of the lath strips was fixed while those at the other ends were fixed only to the base, so as to be removable. The lath strips were wired to the dowels so that one end of the lath would be free to flex after the removable dowel had been removed.

Each coat of the three-coat plaster applied was made up of 50 lb. gypsum cement plaster, 2 lb. vermiculite, and 3 lb. of silica sand. After the batch had been well mixed it was halved. To one half, 31 lb. of water was added to give a relatively stiff mixture; to the other, 37 1/2 lb. of water was added to produce a comparatively soft mixture. The plaster coats were applied to the lath strips so that the finished face was 15/16-inch thickness as determined by wood grounds, the stiff mix being applied to the lath on the right-hand side of the base. After storage under wet burlap over night, the 12 specimens were transferred, four to each of three humidity chambers. The relative humidity in the three chambers into which the specimens were placed were 50, 65, and 95 percent.

The large amount of water in the specimens increased for a time the relative humidity above those fixed by the saturated salt solutions intended to keep the humidity at a constant level. After 7 days' storage of the specimens, a white-coat finish consisting of 1 parts lime putty to 1 part gauging plaster was applied to the set base-coat plaster in thicknesses ranging from 1/16 to 1/8 inches. The specimens were returned to the humidity chambers as soon as the white-coat finish had been applied.

In the 60-hour interval between the application of the brown-coat plaster and the white-coat finish, the free ends of the metal lath strips made with the drier mix of plaster were deflected from their original positions by expansion of the plaster an average of 0.16 inch and those to which the wetter plaster was applied an average of 0.18 inch. After the application of the white-coat plaster the specimens continued to expand, thus causing increased deflections. A pair of specimens having plaster of the two degrees of wetting continued to deflect after 46 days in the chamber with high humidity. The specimen with the drier mix, and without white coat, has deflected 0.47 inch and the specimen having the wetter mix, with white coat, has deflected 0.14 inch. When placed in chambers conditioned to low humidity, the plaster shrank, thus causing the strips to be deflected in the opposite direction. The four specimens which have been in a chamber, the relative humidity of which has been lowered from 55 to 18 percent, have shrunk to cause deflections of the free ends ranging from 0.197 to 0.276 inch. The shrinkage continues.

## 9. CONCLUSIONS

From the observations made during the inspections of the buildings and the subsequent as well as previous laboratory tests which indicated a high degree of dimensional instability of the plaster when subjected to the range of relative humidities not in excess of those encountered in buildings, it has been concluded that the cracking has resulted from this instability. The relative effects of shrinkage of the fibered gypsum cement plaster as revealed by the volumetric shrinkage of cubes of the neat and sanded plasters, items 4, 5, and 6, table 2, and the expansion and contraction of the plaster bars having both sand and vermiculite as the aggregate in causing the plaster to crack have not yet been determined. Doubtless both effects have played a part in causing cracks in the plaster. The measurements of changes of length of specimens of the set plaster on metal lath by means of the comparator have shown that when subjected to large variations in relative humidity the base-coat plasters usually crack, and in a few cases the white-coat finish cracked also. Some of the 3 inch wide strips cut from the 15- by 15-inch specimens of lath and plaster taken from partitions in the hospital building exhibited decided curvature, which increased as the tests proceeded, indicating that the strength of the plaster was sufficient to cause progressive bending of the expanded metal lath. Some of these strips cracked during the tests, presumably when the strength of the plaster was not sufficient to cause further bending of the metal lath.

Although the studies have not been completed, we can, with reasonable assurance, say that the cracking of the plaster has resulted from dimensional instability of the combination of lath and weak plaster. Dimensional changes have doubtless been aggravated by the humidity conditions prevailing within the building during and subsequent to the plastering operations.

It is quite probable that cracking of the plaster on the metal lath partitions will continue through several seasons unless some process for stabilizing the plaster against excessive expansion and contraction with the changes in humidity to which it is normally subjected can be applied.

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For the Director

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